GROUND CONTROL SURVEY REPORT MENDOCINO (HOWARD LAKE SLIDE-TALIAFERRO ANNEX)

GPS SURVEY FOR LIDAR CONTROL

CONTENTS

1. ABSTRACT

This report documents the GPS ground surveys conducted in support of LIDAR data collection for the Mendocino(Howard Lake Slide-Taliferro Annex) area. The surveyed ground control was established on October 22(Mule-M4 Slide) ,2013. The aerial collection was performed with the Optech ALTM Gemini LiDAR Sensor on October 22th, 2013 . The ground control stations were established utilizing the **Leica RX1205 XC** Survey receiver. There were no problems encountered during this survey. The ground survey was conducted at 8 sites utilizing the CORS stations identified on the ***OPUS*** Data sheets. These surveys established "Ground Truth" data at each site.

A Beechcraft Bonanza A36TC, based out of Chino Airport, CA was utilized on this project for the LiDAR Mission. This aircraft was outfitted with an Optech Gemini ALTM 167kHZ system (s/n 07SEN204).

Mission planning parameters for the LiDAR noted below. These lines would be flown using the following settings:

Altitude:	**800 m**
Overlap:	**60 %**
Speed:	**120 kts**
System PRF:	**70 kHz**
Scan Freq:	**64 Hz**
Scan Half Angle:	**10°**
Cross Track Res.:	**0.491 m**
Down Track Res.:	**0.482 m**

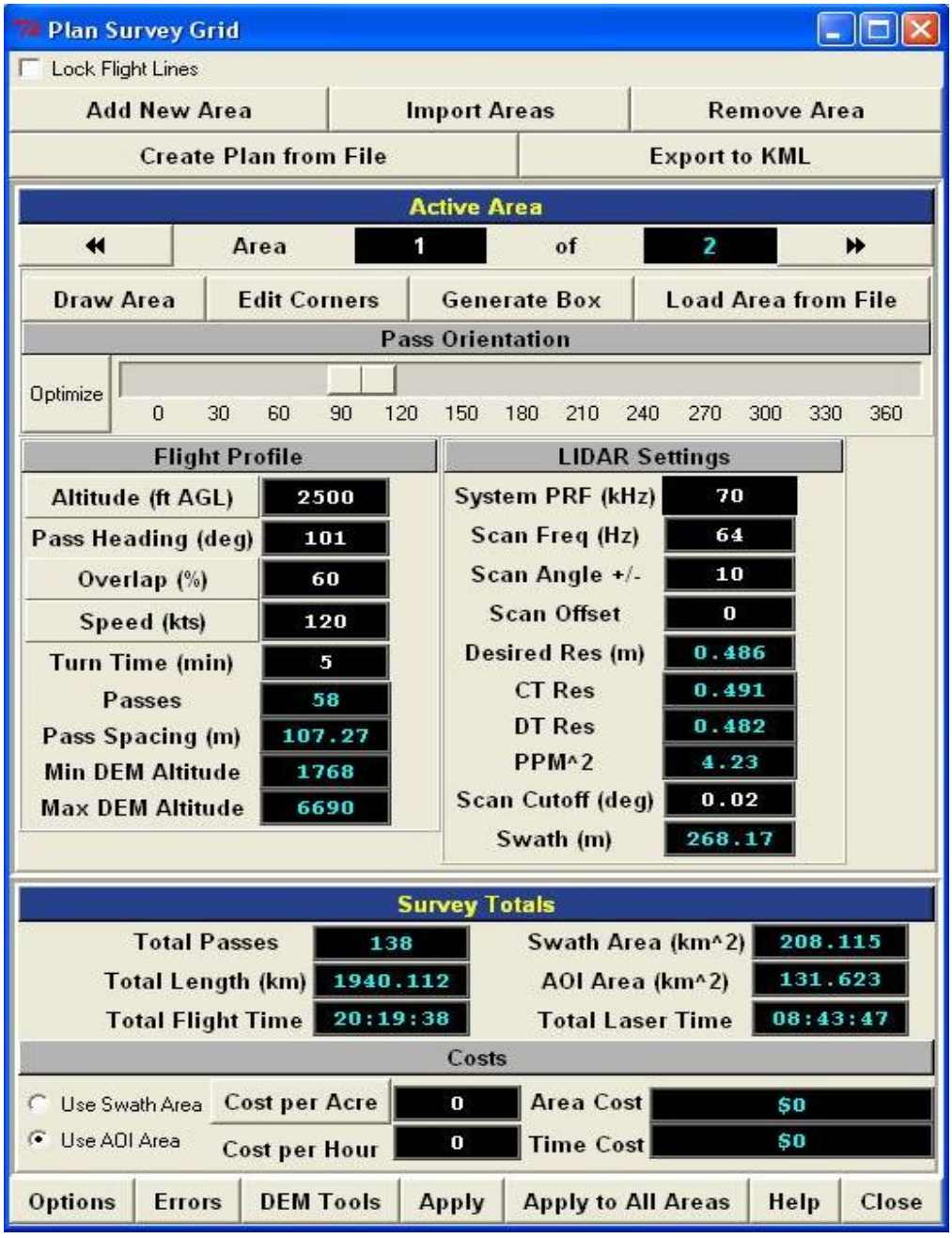
The actual local flight times and duration of flights were controlled by fuel consumption of the aircraft, safety of flight operations in the particular airspace and during times when the GPS constellation was most favorable, producing the highest number of satellites visible in the best geometric configuration relative to the GPS receivers onboard the aircraft as well as at the master stations on the ground. A standard of flying with no less than 6 satellites visible and a PDOP (position dilution of precision) of less than 3.0 was adopted.

Statistical comparisons were made between ground truth points collected in the survey and airborne LIDAR points .

Comparisons were also made between the survey points and the LIDAR derived terrain surface. These comparisons provide an additional verification of the LIDAR data against the survey data.

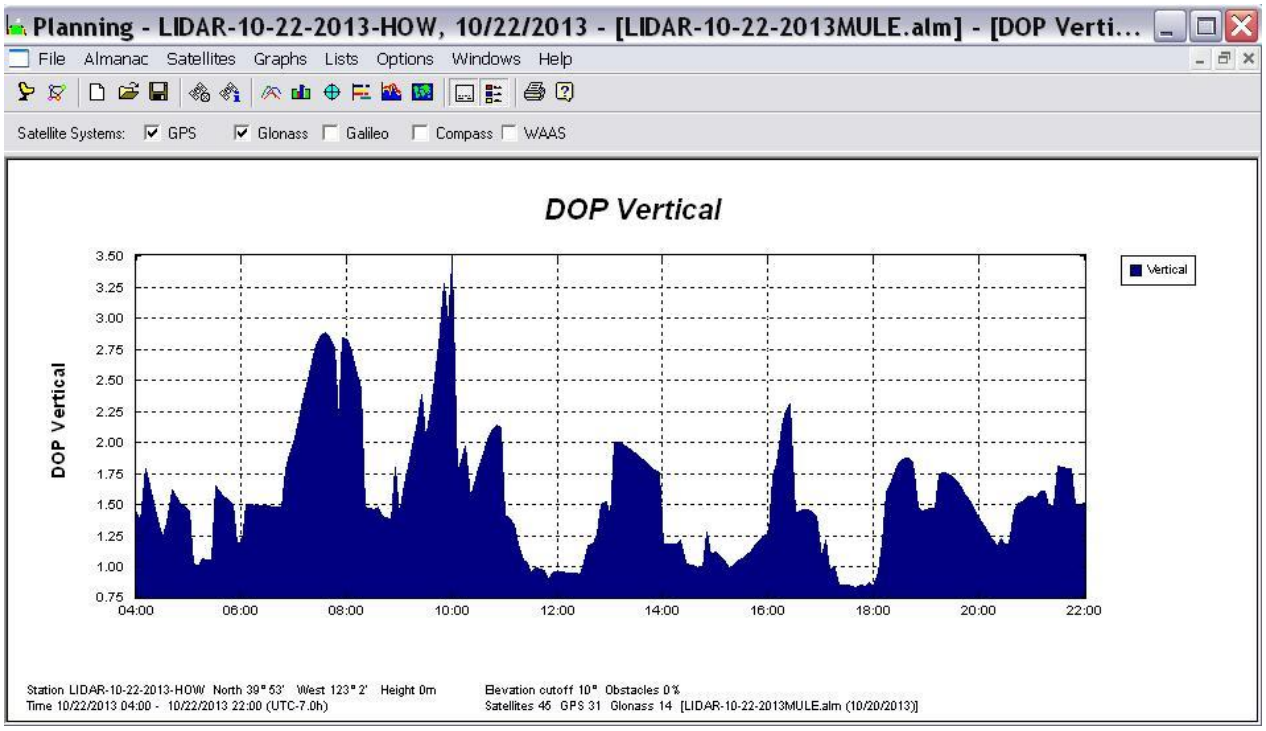
The horizontal and vertical datum used for this project are listed below:

Vertical Datum:	**NAVD88, Geoid12A**
Horizontal Datum:	**NAD83**
Projection:	**UTM Zone 10**
Units:	**METERS**

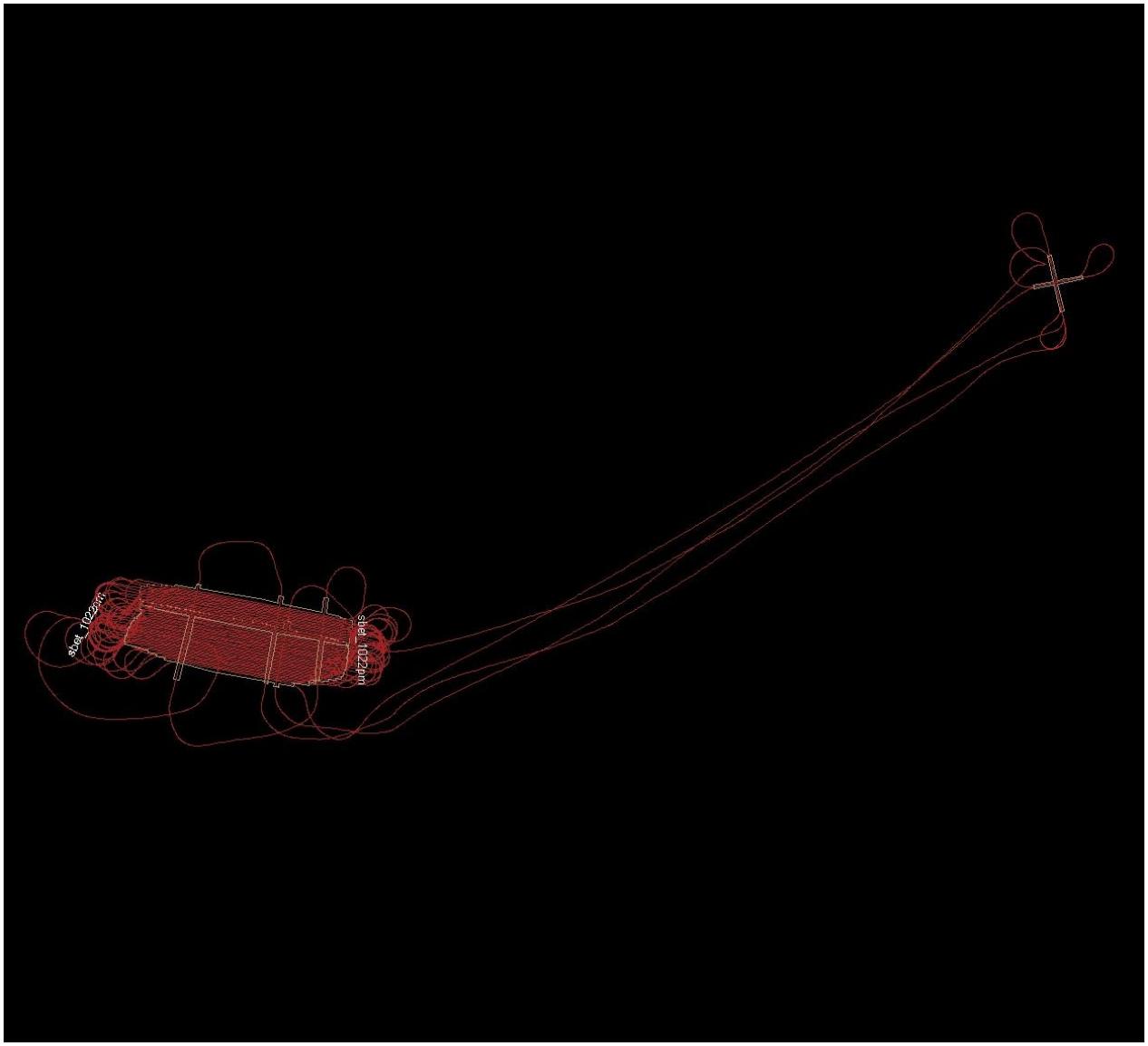


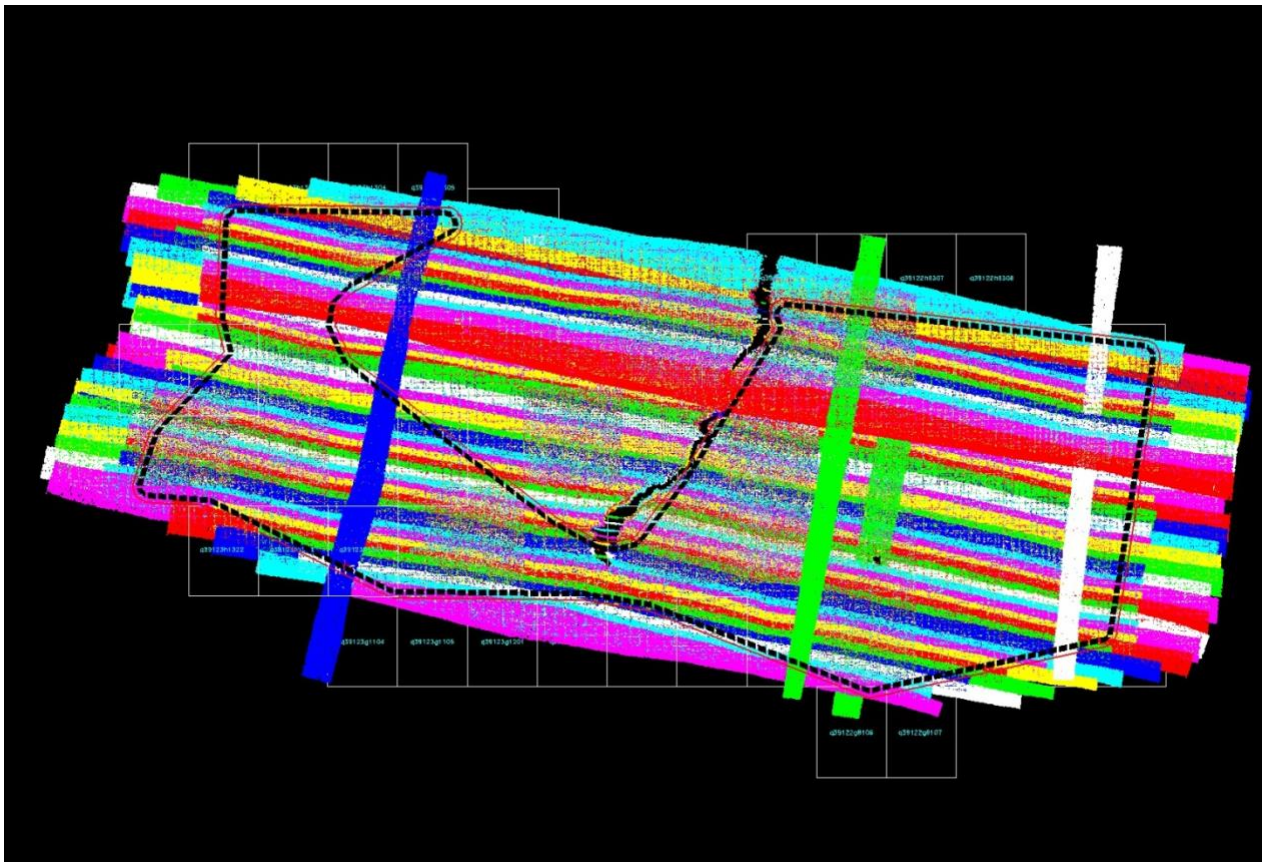
LiDAR MISSION PARAMETERS

DMI always checked PDOP before commencing flight (weather permitting) – *next page* shows data collection and dates with PDOP report October 22, 2013.


Planning - LIDAR-10-22-2013-HOW, 10/22/2013 - [LIDAR-10-22-2013MULE.alm] - [DOP Verti...
File Almanac Satellites Graphs Lists Options Windows Help
Satellite Systems: GPS Glonass Galileo Compass WAAS
DOP Vertical
DOP Vertical
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Vertical
Station LIDAR-10-22-2013-HOW North 39° 53' West 123° 2' Height 0m
Time 10/22/2013 04:00 - 10/22/2013 22:00 (UTC-7.0h)
Elevation cutoff 10° Obstacles 0%
Satellites 46 GPS 31 Glonass 14 [LIDAR-10-22-2013MULE.alm (10/20/2013)]

SBET IMAGES and FLIGHT LINES





OPUS: Online Positioning User Service – Solution Report
@ ½ Second

Ground Receiver HT 1 - 10/22/2013

START: 2013/10/22 13:12:00
STOP: 2013/10/22 23:13:00

ANT NAME: LEIAX1202 NONE # FIXED AMB: 108 / 112 : 96%

ARP HEIGHT: 1.8738 OVERALL RMS: 0.013(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000)			IGS08 (EPOCH:2013.8076)	
X:	-2663170.469(m)	0.010(m)	-2663171.342(m)	0.010(m)
Y:	-4118790.675(m)	0.008(m)	-4118789.392(m)	0.008(m)
Z:	4066104.560(m)	0.008(m)	4066104.550(m)	0.008(m)
LAT:	39 50 53.34883	0.007(m)	39 50 53.36111	0.007(m)
E LON:	237 6 49.24629	0.005(m)	237 6 49.18617	0.005(m)
W LON:	122 53 10.75371	0.005(m)	122 53 10.81383	0.005(m)
EL HGT:	1637.023(m)	0.012(m)	1636.554(m)	0.012(m)
ORTHO HGT:	1664.909(m)	0.030(m)	[NAVD88 (Computed using GEOID12A)]	

	UTM COORDINATES STATE PLANE COORDINATES	
	UTM (Zone 10)	SPC (0401 CA 1)
Northing (Y) [meters]	4410910.029	557549.866
Easting (X) [meters]	509725.111	1924144.425
Convergence [degrees]	0.07284080	-0.57955105
Point Scale	0.99960116	1.00004169
Combined Factor	0.99934451	0.99978493

US NATIONAL GRID DESIGNATOR: 10SEK0972510910(NAD 83) **BASE**

STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DN9089	P334 SHEETIRON_CN2007 CORS ARP	N392936.918	W1224409.083	41442.2
DN7390	P335 BLACKBUTTECN2008 CORS ARP	N394334.270	W1225225.038	13602.6
DN7378	P319 HOGHOLERDGCN2004 CORS ARP	N394225.535	W1231742.229	38382.9

NEAREST NGS PUBLISHED CONTROL POINT

KT0688	T 601	N395050.	W1225258.	320.0

Ground Receiver HT 2 - 10/22/2013

START: 2013/10/22 13:21:00
STOP: 2013/10/22 23:16:30

ANT NAME: LEIAX1202 NONE # FIXED AMB: 160 / 172 : 93%

ARP HEIGHT: 1.7988 OVERALL RMS: 0.015(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000)			IGS08 (EPOCH:2013.8076)	
X:	-2663217.427(m)	0.011(m)	-2663218.300(m)	0.011(m)
Y:	-4118733.663(m)	0.017(m)	-4118732.380(m)	0.017(m)
Z:	4066122.953(m)	0.016(m)	4066122.943(m)	0.016(m)
LAT:	39 50 54.27136	0.004(m)	39 50 54.28364	0.004(m)
E LON:	237 6 46.28616	0.004(m)	237 6 46.22603	0.004(m)
W LON:	122 53 13.71384	0.004(m)	122 53 13.77397	0.004(m)
EL HGT:	1631.628(m)	0.026(m)	1631.158(m)	0.026(m)
ORTHO HGT:	1659.513(m)	0.049(m)	[NAVD88 (Computed using GEOID12A)]	

	UTM COORDINATES UTM (Zone 10)	STATE PLANE COORDINATES SPC (0401 CA 1)
Northing (Y) [meters]	4410938.382	557579.031
Easting (X) [meters]	509654.732	1924074.342
Convergence [degrees]	0.07231432	-0.58008871
Point Scale	0.99960115	1.00004162
Combined Factor	0.99934535	0.99978570

US NATIONAL GRID DESIGNATOR: 10SEK0965410938(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DN9089	P334 SHEETIRON_CN2007 CORS ARP	N392936.918	W1224409.083	41491.2
DN7378	P319 HOGHOLERDGCN2004 CORS ARP	N394225.535	W1231742.229	38330.0
DN7390	P335 BLACKBUTTECN2008 CORS ARP	N394334.270	W1225225.038	13637.0

NEAREST NGS PUBLISHED CONTROL POINT

KT0687	5400.2	USGS	N395100.	W1225327.	361.8

2. GROUND TRUTH SUMMARY

Surveys were conducted to establish ground truth data at representative sites throughout the project area. These sites were selected on the basis of the optimizing visibility needed for the LIDAR survey over the area.

HOWARD_TALIFERRO LIDAR 2013/DIGITAL MAPPING INC./UTM 10

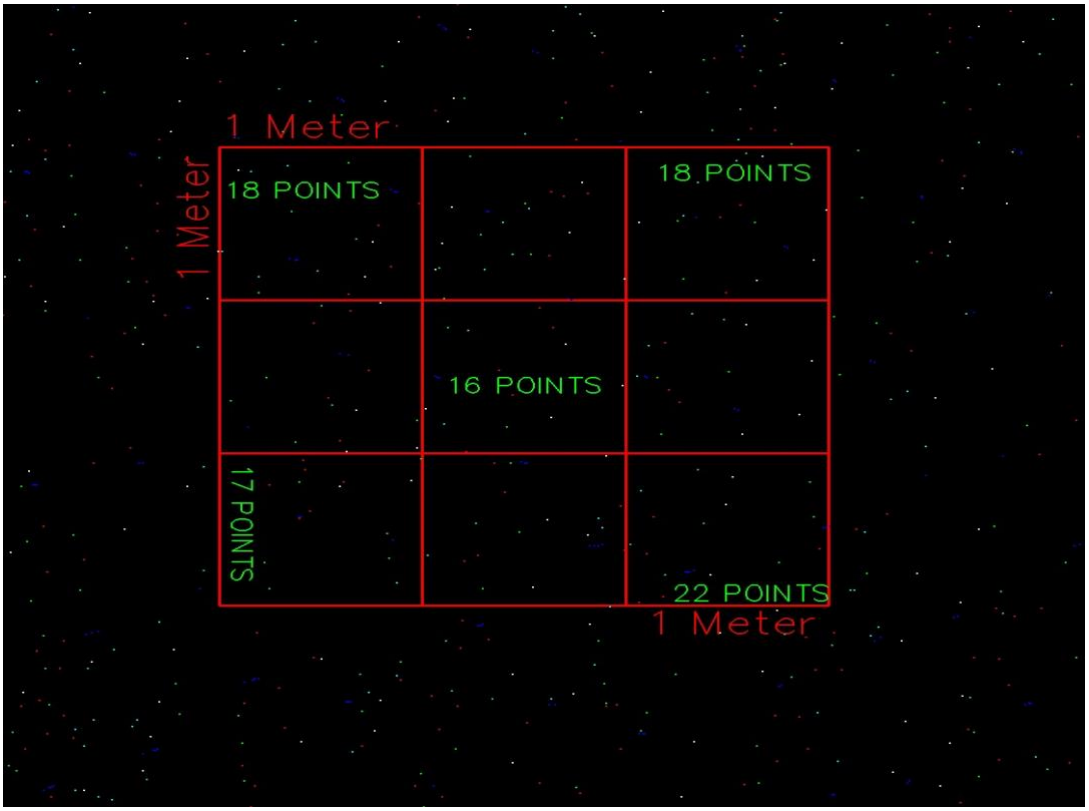
AERIAL POINT#	LATITUDE	LONGITUDE	NORTH (M)	EAST (M)	TARGET ELEV.	DESCRIPTION
HT 2	39°55'31.67779"N	123°02'59.95751"W	4419485.929	495728.387	1330.016	SET 60SPIKE
HT 3	39°53'33.86789"N	123°04'53.90043"W	4415855.827	493020.427	1445.369	SET 60SPIKE
HT 5	39°52'44.94547"N	123°05'04.03514"W	4414347.772	492778.322	1398.526	SET 60SPIKE
HT 7	39°54'40.09599"N	122°59'48.63660"W	4417894.462	500269.787	1143.550	SET 60SPIKE
HT 8	39°54'23.68349"N	122°56'37.55543"W	4417389.970	504806.704	1859.634	SET 60SPIKE
HT 9	39°53'15.93105"N	122°58'45.80152"W	4415299.848	501762.199	1198.210	SET 60SPIKE
HT 10	39°52'02.32587"N	123°00'09.26920"W	4413030.403	499779.793	1370.680	SET 60SPIKE
HT 11	39°52'13.08789"N	122°57'28.10558"W	4413363.044	503608.378	1816.580	SET 60SPIKE

3. DATA ANALYSIS

Data analysis was accomplished by comparing ground truth checkpoints with LIDAR points from the edited data set. The only exception to this were the ground truth points collected under the tree/forest canopy, where comparisons were made with LIDAR pulses that fell near known positions. This is because fewer LIDAR pulses are able to reach the ground in heavily forested areas, so the point spacing is larger than in cleared areas.

The base stations used to collect survey data were included in the static GPS network, and were selected on the basis of their having an unobstructed view of the sky, as well as being in a location considered favorable for collecting ground truth data. The vertical and horizontal accuracy of each base station was determined by the statistical tests performed in the least squares adjustment process.

Note that the edited LIDAR points are simply a subset of the raw LIDAR points. The points that fell above the ground surface on vegetation canopies, buildings, or other obstructions were removed from the data set. Comparisons were also made between the survey points and the LIDAR derived terrain surface. These comparisons provide an additional verification of the LIDAR data against the survey data.



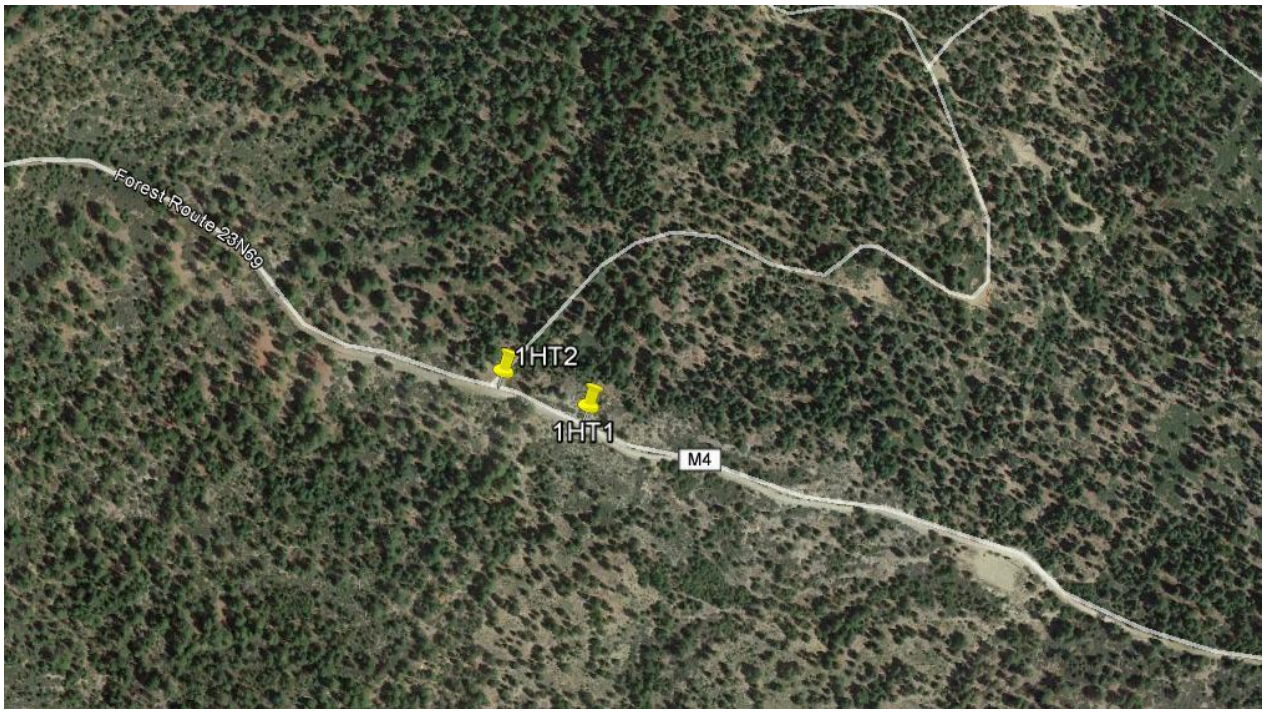
ONE METER SQUARE > 9 points

LiDAR POINT CHECK

Our ground control check from QA/QC supported in attached documents

4. GROUND TRUTH SURVEY

A. Map of Control Point Locations/ Base Stations



10/22/2013

B. Ground Truth Analysis of LIDAR Points

GROUND TRUTH ANALYSIS

Comparison of LIDAR Points to Ground Truth Points

GeoCue software was used to compare known , position established and occupied for twenty-minutes , control points versus identical position of LiDAR XYZ point data. The intensity image produced from the *LIDAR collection, was used to pick areas where ground and truth data collection could be collected. In areas of flat terrain or areas where detail is important it can be used as areas to collect X,Y,Z ground truth data for accessing the accuracy of the LIDAR data. Ground truth data can be collected using conventional survey techniques or DGPS techniques.*

SPATIAL REFERENCE FRAMEWORK

Vertical Datum **NAVD88, Geoid12A**
Horizontal Datum **NAD83**
Projection **UTM Zone 10**
Units **METERS**

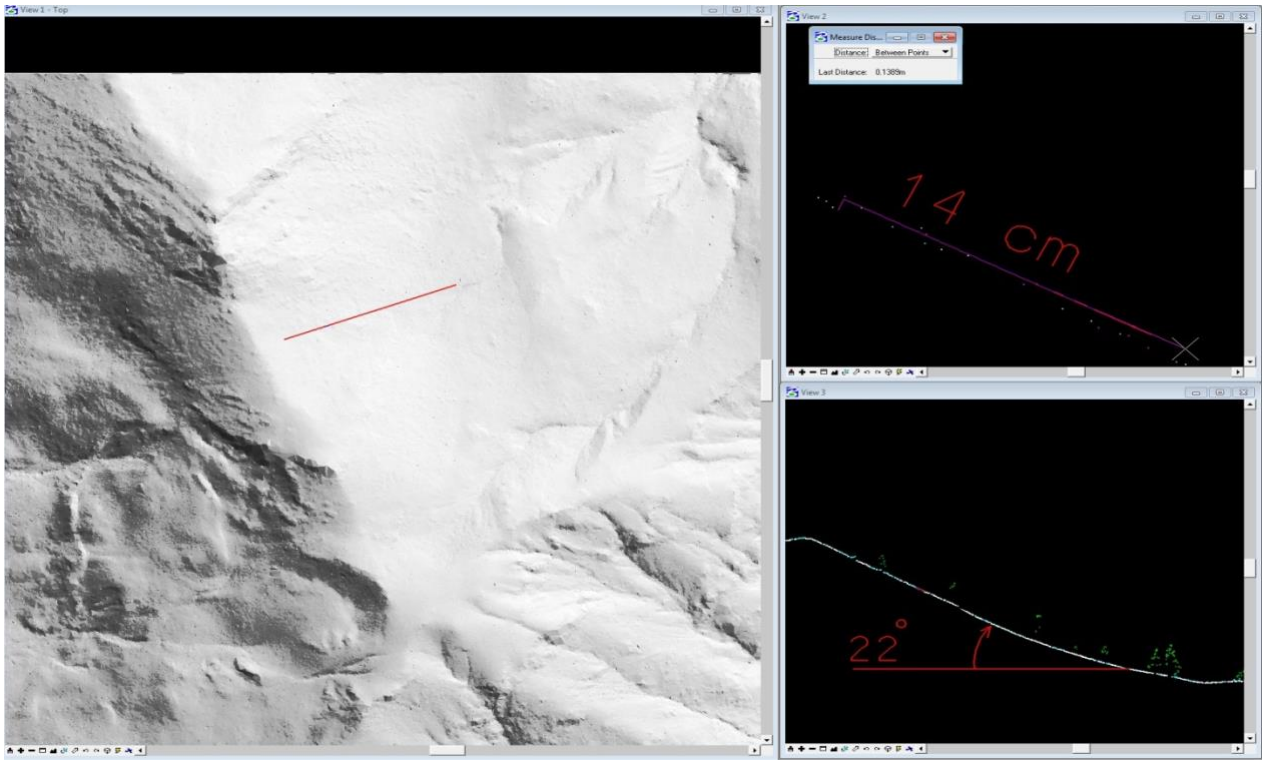
Ground Control Z vs. Aerial Surveyed/ Laser Pointing Z (QA/QC)

HOWARD-TALIAFERRO

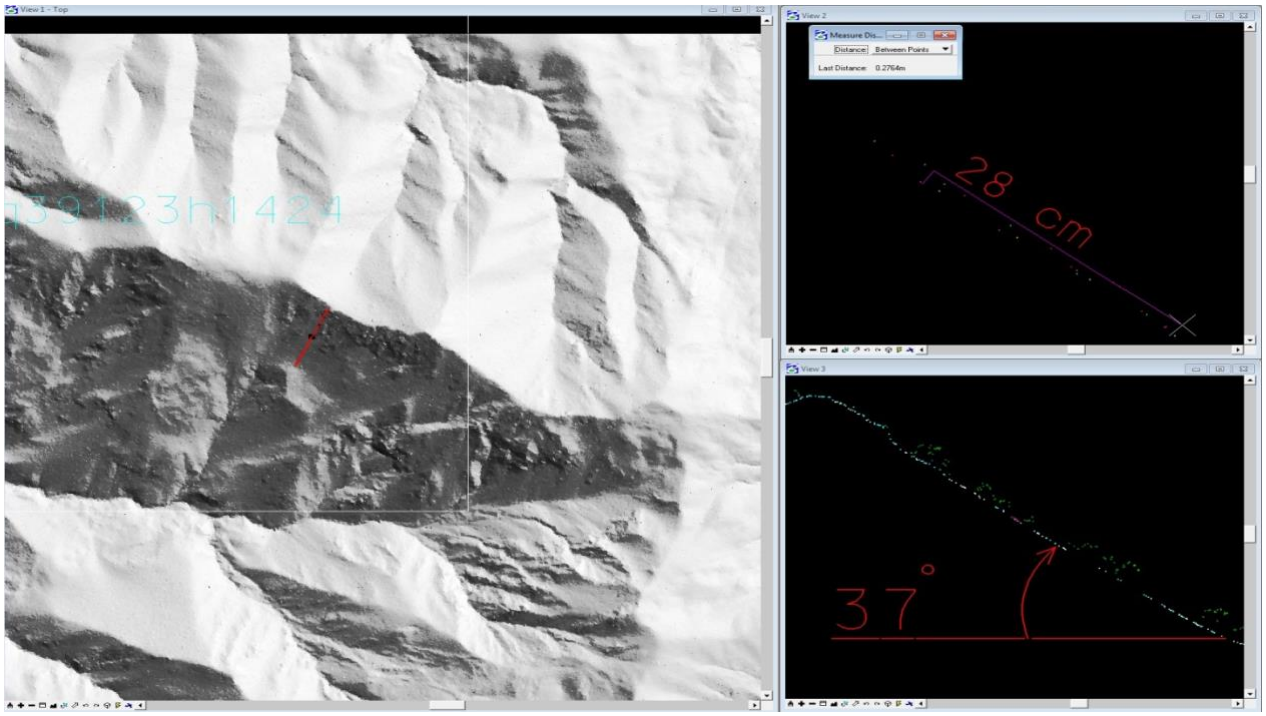
Number	Easting	Northing	Known Z	Laser Z	Dz
HT2	495728.387	4419485.929	1330.016	1329.950	-0.066
HT3	493020.427	4415855.827	1445.369	1445.490	+0.121
HT5	492778.322	4414347.772	1398.526	1398.590	+0.064
HT7	500269.787	4417894.462	1143.550	1143.520	-0.030
HT8	504806.704	4417389.970	1859.634	1859.670	+0.036
HT9	501762.199	4415299.848	1198.210	1198.190	-0.020
HT10	499779.793	4413030.403	1370.680	1370.680	+0.000
HT11	503608.378	4413363.044	1816.580	1816.500	-0.080

Average dz	+0.003
Minimum dz	-0.080
Maximum dz	+0.121
Average magnitude	0.052
Root mean square	0.063
Std deviation	0.068

22 DEGREE SLOPE



37 DEGREE SLOPE



FLAT AREA